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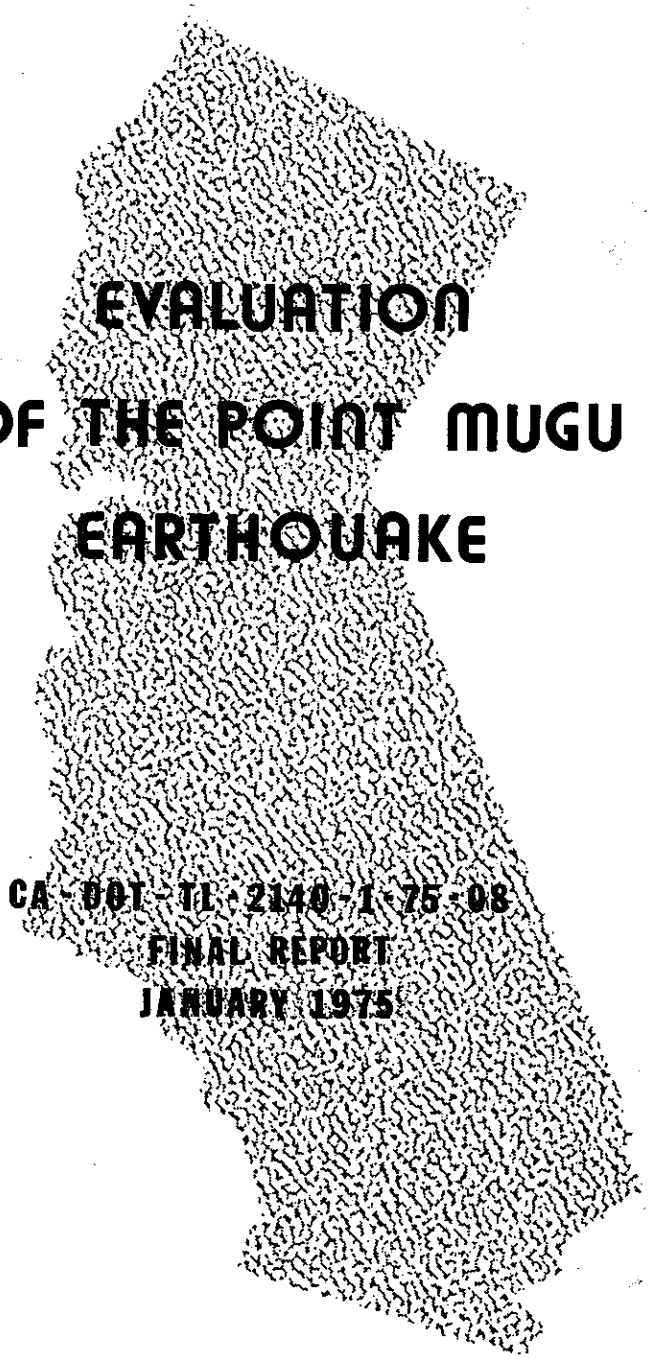
RESEARCH REPORT



EVALUATION OF THE POINT MUGU EARTHQUAKE

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FINAL REPORT
JANUARY 1975

Prepared in Cooperation with the U.S. Department of Transportation,
Federal Highway Administration

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16. ABSTRACT

This report presents a summary of damage caused by the February 21, 1973 earthquake near Point Mugu, California to existing highway facilities in the area. Also presented are the results of a computer analysis of the ground motion and a prediction of the damage this earthquake would have caused at a proposed interchange between Routes 101/232/1 now under design.

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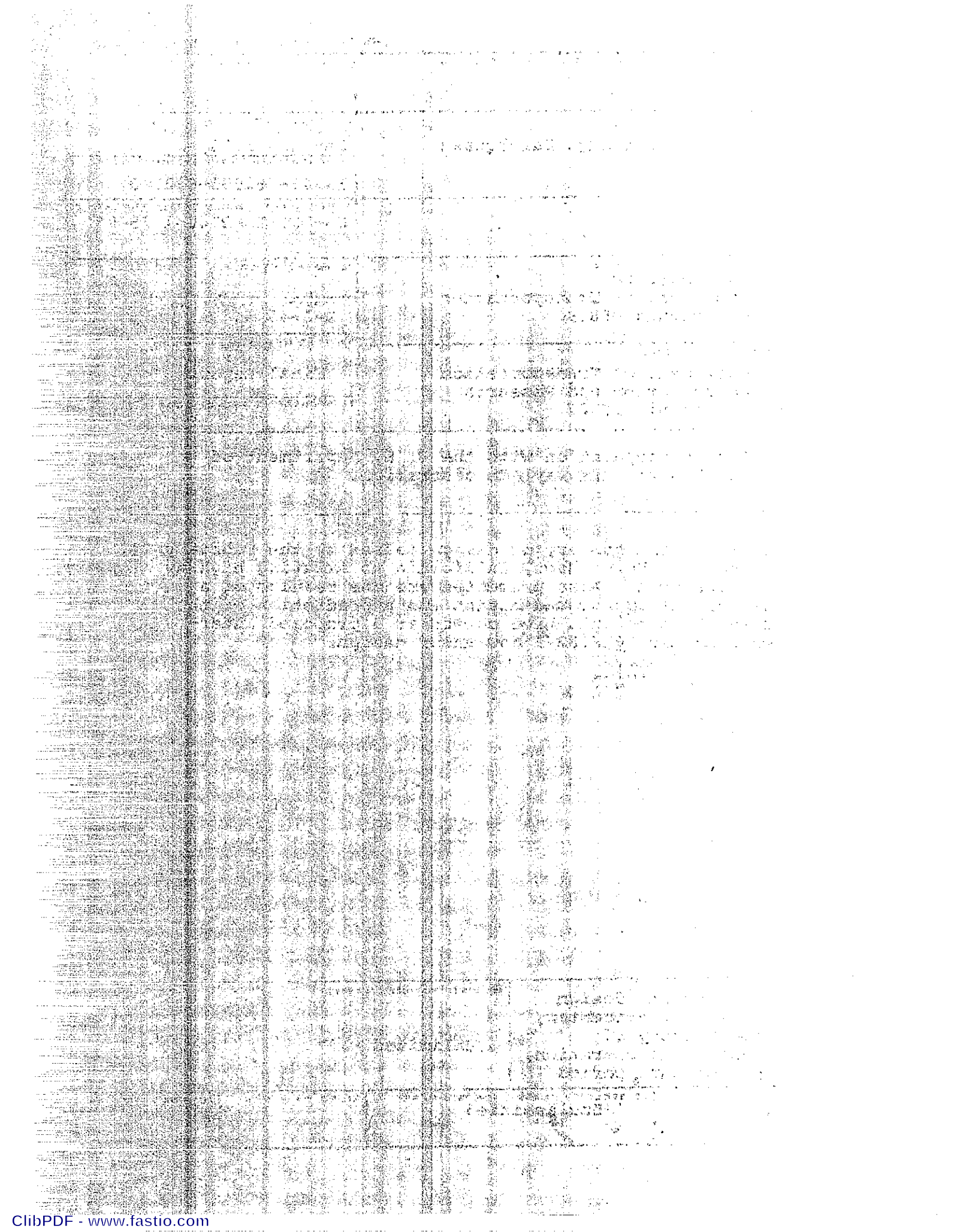


STATE OF CALIFORNIA
DEPARTMENT OF TRANSPORTATION
DIVISION OF CONSTRUCTION AND RESEARCH
TRANSPORTATION LABORATORY

January 1975

TL 632140 5
FHWA No. D-8-45

Mr. R. J. Datel
Chief Engineer

Dear Sir:

I have reviewed and now submit for your information this final research report titled:

EVALUATION OF THE POINT MUGU

EARTHQUAKE OF February 21, 1973

FINAL REPORT

Study made by..... Geotechnical Branch

Under the Supervision of..... Raymond A. Forsyth

Principal Investigator..... D. L. Durr

Co-Investigator..... R. H. Prysock

Report Prepared By..... D. J. Kuhl

Very truly yours,

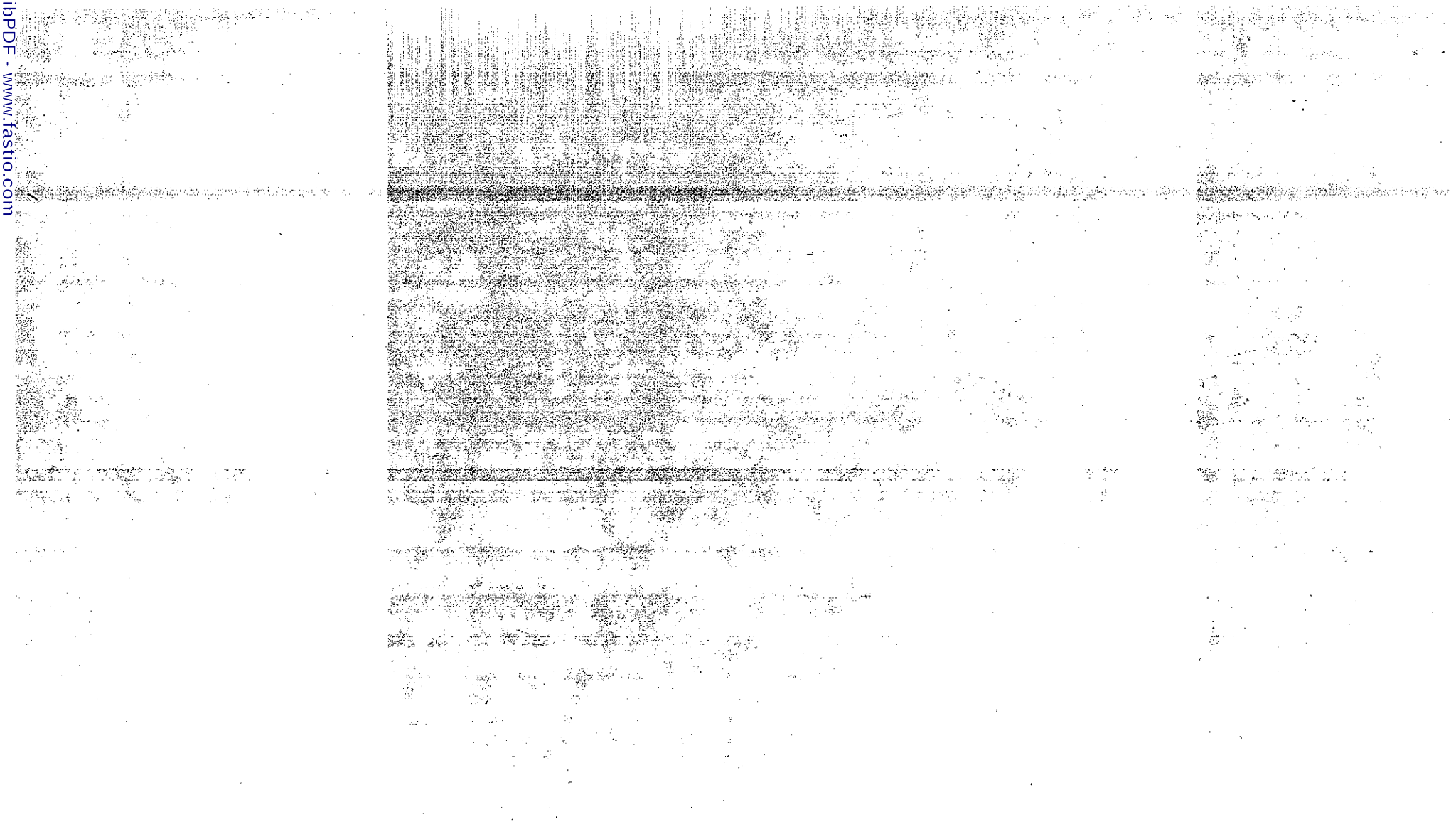
JOHN L. BEATON
Chief Engineer, Transportation Laboratory

Attachment

TABLE OF CONTENTS

ACKNOWLEDGMENTS

The author gratefully acknowledges the guidance of Mr. James Gates of the Office of Structures in the application of the latest methods of seismic ground reponse analysis. Appreciation is also extended to Mr. Christopher J. Masklee of the Transportation Laboratory for his assistance in computer analysis and Mr. Stanley K. Takahashi of the U. S. Naval Civil Engineering Laboratory, Port Hueneme, for supplying seismograph records for the "Point Mugu" earthquake.



I. INTRODUCTION

This report presents the findings of an investigation concerning the Point Mugu, California, earthquake of February 21, 1973. The first part of the investigation was simply a field survey of damage to existing highway facilities in the immediate area. The second part of the investigation was of a hypothetical nature and involved determining ground motion at the proposed Routes 101/232/1 interchange, and then estimating the damage that would have been sustained had the interchange been in existance.

The proposed interchange will include eight connector roads, all crossing over the main routes, plus bridge construction for Route 1 over Route 101 and over Gonzales Road south of the proposed site.

At the time of this writing the estimated location of the earthquake's epicenter was 34° N 119° W, about 15 miles southeast of the interchange location. The point of energy release was at a depth of 10 to 15 miles. Magnitude for the main shock was approximately 5.75 on the Richter scale. Preliminary fault investigation indicated thrust movement along a relatively short fault associated with the Malibu-Santa Monica-Raymond Hill Zone.

Surface ground motion in three orthoganal directions was recorded by a USGS strong motion seismograph at the Naval Civil Engineering Laboratory, Port Hueneme, California. The location of the instrument was approximately 12 miles northwest of the epicenter, as shown in Figure 1.

Prior to the Point Mugu earthquake a report had been prepared for the Division of Highways by the consulting firm of Woodward-McNeill and Associates concerning seismicity and dynamic response of the interchange site[1]. Their findings were the result of an in-depth field and laboratory investigation into the following subjects:

- Site conditions
- Local and regional seismicity
- Local and regional geology
- Expected earthquake motions
- Ground, embankment, and structural response
- Slope stability
- Liquefaction potential
- Seismically induced soil densification
- Soil-structure interaction

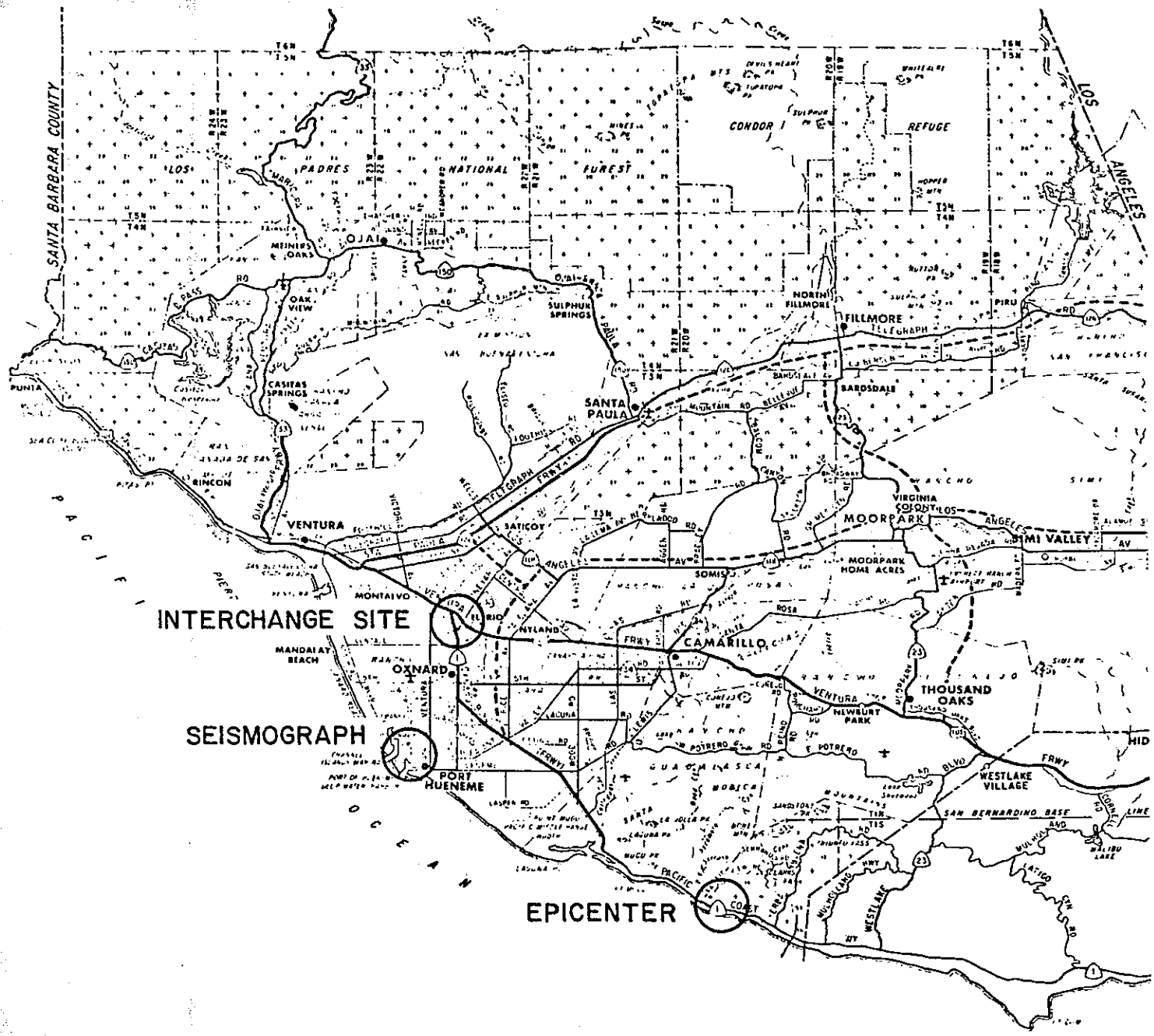


Fig. 1 SITE MAP

Conclusions and recommendations were presented concerning site seismicity, design earthquake motion, and procedures for minimizing earthquake damage.

In this report, seismic data recorded at Port Hueneme are extrapolated to estimate ground motion at the interchange site. Damage potential for this motion is then evaluated by comparison with seismic response results and design earthquake motions as presented in the Woodward-McNeill report.

II. CONCLUSIONS AND RECOMMENDATIONS

With the provision that the Routes 101/232/1 interchange will be designed and constructed utilizing the recommendations and conclusions presented in the Woodward-McNeill report, it is concluded that there would have been little or no damage to the proposed facility due to the February 21, 1973 earthquake near Point Mugu. The interchange structures would be expected to respond in a manner similar to those already in existence near the site. Bridges would not be structurally affected; however, dissimilar response of abutments and superstructures would likely cause enlargement of paving notch separations. Spalling, if any, would be localized, and confined to areas of rigidity change. Soil surrounding abutments and fixtures such as bridge railing would show signs of minor movement. Liquefaction would not be likely to occur and seismic settlement would be very minor in nature and not significantly affect the continuing operation of the interchange.

It is further concluded that analytical methods and procedures used herein are useful tools for estimating the ground response at proposed construction sites due to selected design earthquakes.

In summary, it is recommended that no additional safeguards against earthquake damage beyond those put forth in the Woodward-McNeill report be incorporated in the Routes 101/232/1 interchange design.

III. DISCUSSION

A. Damage to Existing Highway Facilities

A field review of the highway facilities in the vicinity of the earthquake was conducted by the Transportation Laboratory shortly after the quake. The following is a summary of the findings.

Although most highway structures in the Oxnard Plain area showed signs of movement, very little damage was evident. Nearly all bridge abutments indicated working at the base, with cracking and mounding of the adjacent soil. Paving notch separation and skew were altered to a small degree on a few bridge structures. Minor spalling was found at three locations; Routes 101/34 Separation, Almond Avenue Overcrossing, and Routes 101/232 Separation. Two light fixtures on a Route 1 pedestrian crossing were knocked from their mountings. Pipes and railing at bridge structures bore scratches indicating dynamic movement. A rock-fall occurred in a rock cut on Highway 1 at Mugu Rock. A small slipout developed in an embankment on Highway 1 about one mile north of the Los Angeles County Line. A maximum of one inch vertical movement was involved.

B. Seismic Data for the Point Mugu Earthquake

The most significant seismic data available concerning the February 21, 1973 earthquake were recorded on the seismograph at Port Hueneme. A graphic time history of motion plotted by the instrument is included as Figure 2. Analysis of this record established the following parameters characterizing ground surface motion at Port Hueneme:

Maximum Acceleration	0.13 g
Predominant Period	0.25 sec.
Duration of strong motion	6-7 sec.

C. Analysis of Ground Motion

In order to evaluate the response of the proposed Oxnard interchange to the Point Mugu quake, it was first necessary to determine the earthquake ground motion design parameters for the project. It was assumed for the purposes of this investigation, that the future interchange will incorporate the conclusions and recommendations set forth in the Woodward-McNeill report. These recommendations reflect the five sets of design earthquake parameters presented in Table 1. The "OBE", "MBE", and "DBE" designations stand for "operational basis earthquake", "maintenance basis earthquake", and "design basis earthquake", respectively.

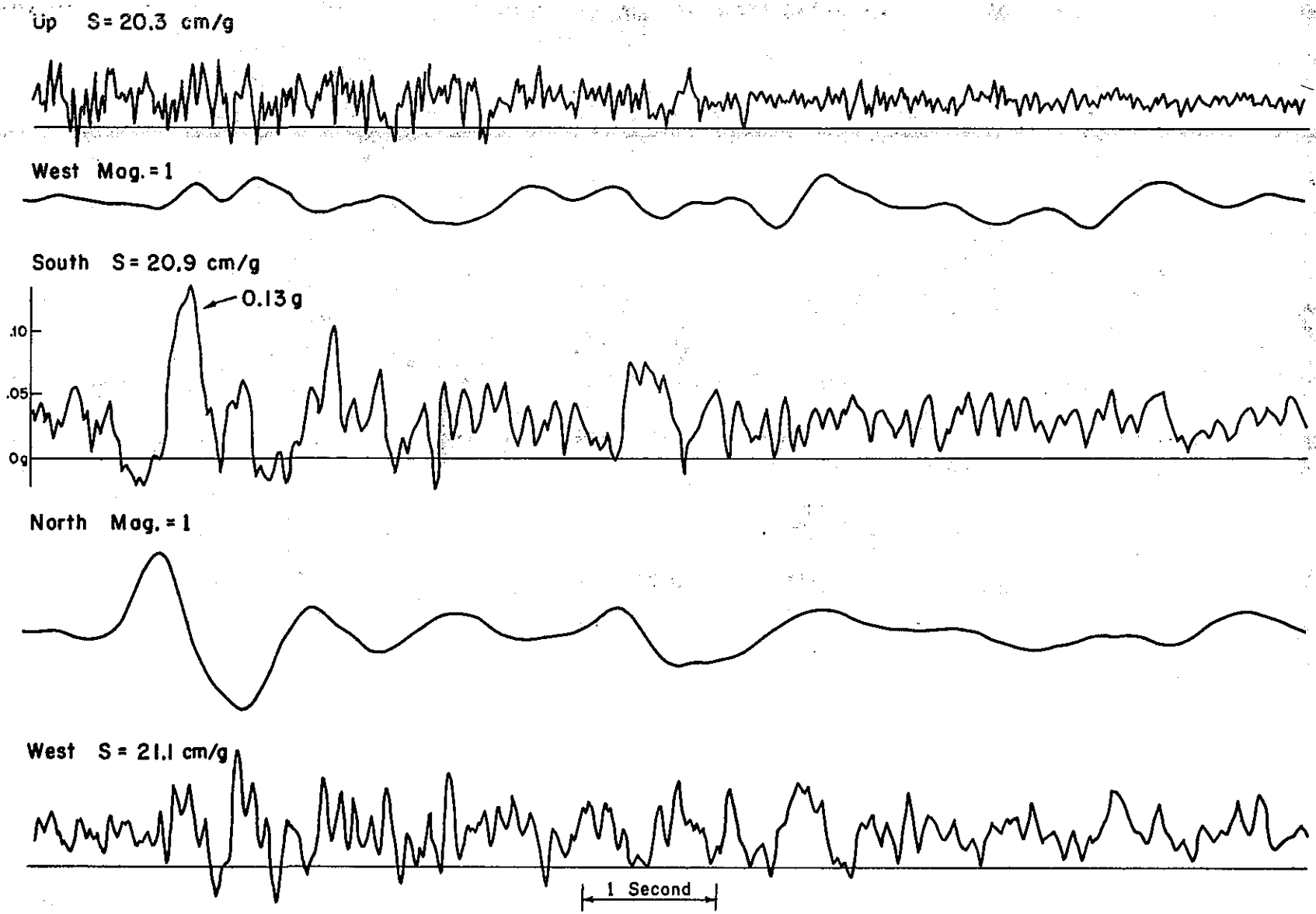


Fig.2 PORT HUENEME ACCELEROGRAPH RECORD

TABLE 1

SUMMARY OF DESIGN EARTHQUAKE CHARACTERISTICS (Ref. 1)

Earthquake	Fault	Mag.	Maximum Bedrock Accel. (g)	Maximum Surface Accel. (g)	Predominant Period (Sec)	Duration of Strong Motion Shaking (sec)	Equivalent Cycles for 70% of Maximum Acceleration	Probability of Occurance 50 yrs.	Probability of Occurance 100 yrs.
OBE-1	Oak Ridge	5.3	0.20	0.26	0.23	10	8	0.5	0.8
OBE-2	San Andreas	7.5	0.10	0.20	0.45	40	19	0.3	0.5
MBE-1	Oak Ridge	5.6	0.40	0.33	0.23	12	9	0.1	0.2
DBE-1	San Andreas	8.5	0.19	0.30	0.50	60	28	---	---
DBE-2	Oak Ridge	6.8	0.62	0.45	0.36	25	15	---	---

The design guidelines presented in the report were as follows:

1. Design interchange facilities to withstand OBE-1 and OBE-2 earthquakes with little or no damage.

2. Design interchange facilities to withstand MBE-1 event with repairable damage.

3. Design interchange facilities to maximize public safety for DBE-1 and DBE-2 events realizing that the interchange may not be salvageable after the earthquake.

The next step in the analysis required the determination of the characteristics of surface ground motion at the interchange site during the Point Mugu earthquake. To this end, extensive use of the computer program "SHAKE 3" was required.

"SHAKE 3" is a computer program for analyzing earthquake response of horizontally layered soil deposits[2]. A given ground motion can be introduced at any layer in a deposit and the response can be obtained at any desired layer. Necessary information for such an analysis includes a soil profile and material properties for the soils, and a digitized record of the ground motion to be applied. If there is no digitized record available for a given earthquake, the program is capable of modifying the ground motion parameters for an existing earthquake record so that the desired ground motion is characterized.

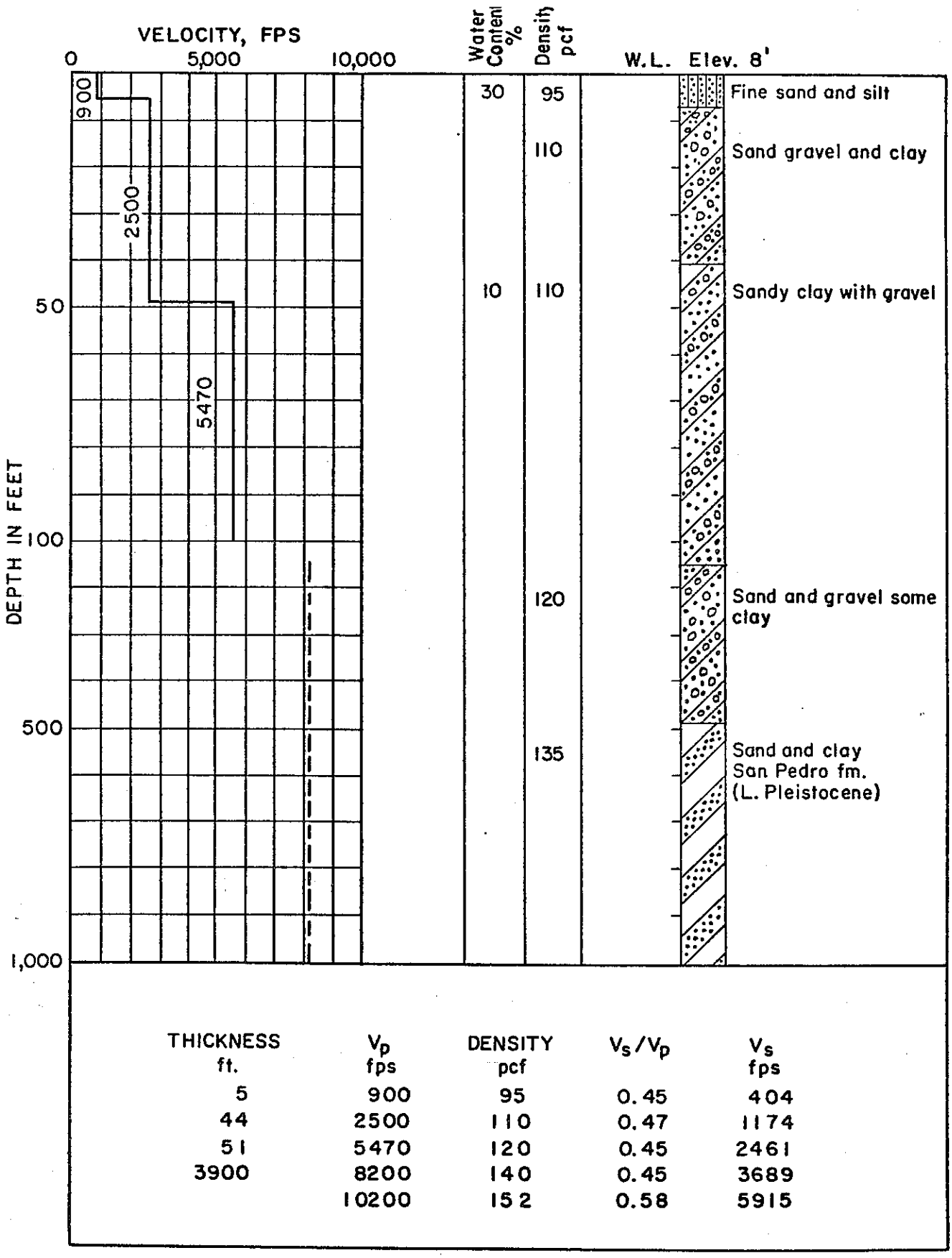
The effort to determine surface ground response at the site of the proposed interchange due to the February 21 earthquake was based on surface ground motion parameters as recorded at Port Hueneme during the event. The following paragraphs outline the procedure employed in taking the recorded data and extrapolating it to represent surface ground motion at the interchange site:

1. Soil profile and material properties beneath the Port Hueneme seismograph were taken from a publication release by the California Department of Mines and Geology[3], Figure 3.

2. After determining that no digitized record of the Point Mugu event was available, the existing record of the 1940 El Centro earthquake was selected for use as the excitation motion.

3. Using the surface ground motion parameters from Port Hueneme and "SHAKE 3" the El Centro record was adjusted to more closely typify the Point Mugu earthquake and then applied to a computer model of the soil strata below the seismograph. This analysis yielded a time history of bedrock motion at this location.

4. Moving to the interchange site, soil profile and material properties corresponding to four locations within the boundaries of the proposed interchange were taken from boring profiles presented in the Woodward-McNeill report, Figure 4.



THICKNESS ft.	V_p fps	DENSITY pcf	V_s/V_p	V_s fps
5	900	95	0.45	404
44	2500	110	0.47	1174
51	5470	120	0.45	2461
3900	8200	140	0.45	3689
	10200	152	0.58	5915

Fig.3 SOIL PROFILE AND MATERIAL CHARACTERISTICS FOR THE PORT HUENEME SEISMIC STATION

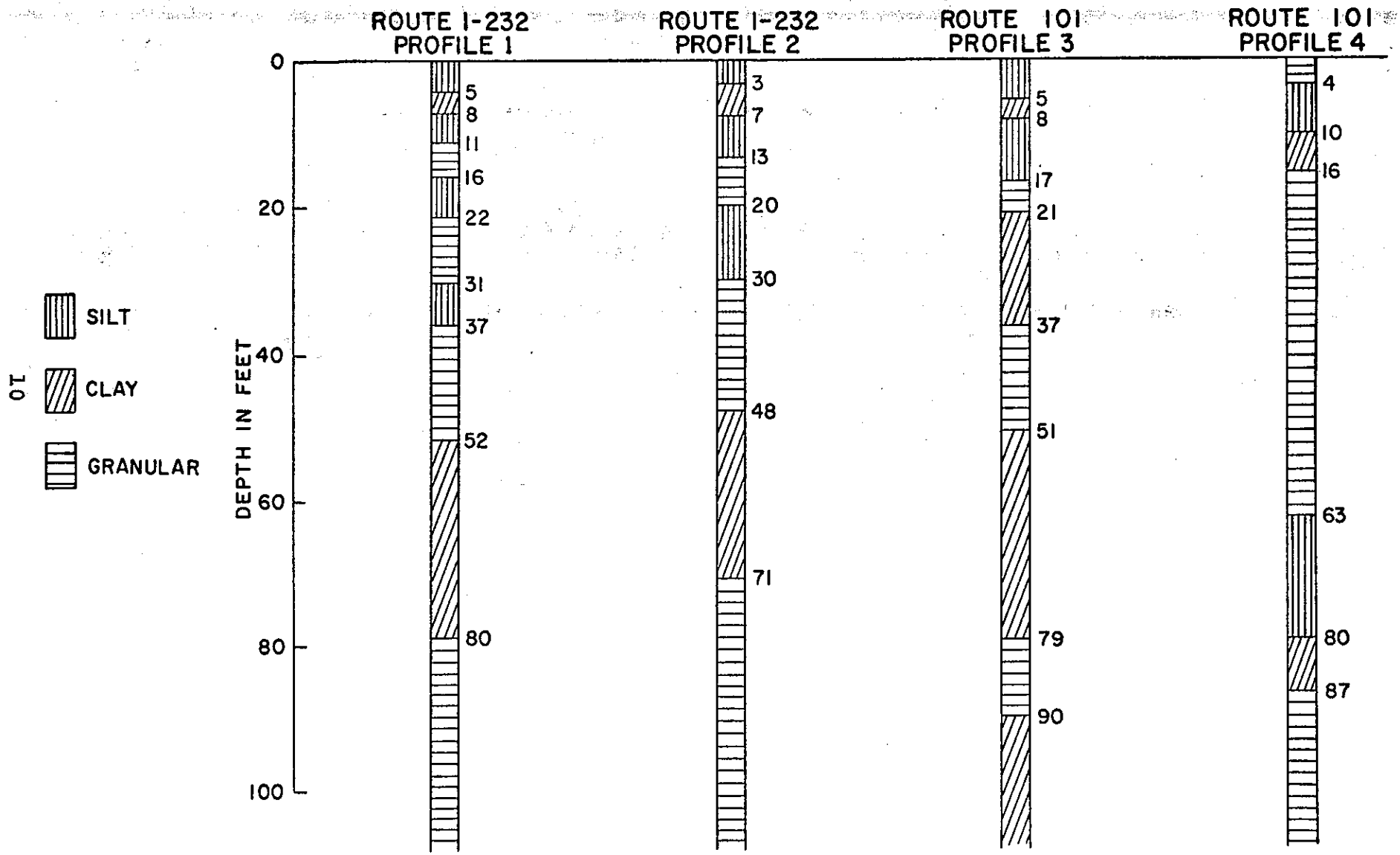


Fig. 4 SOIL PROFILES, ROUTES 101/232/1

5. It was determined from a number of estimated epicentral locations that the proposed site lay approximately 3 miles farther from the source of the Point Mugu earthquake than the seismograph installation. Accounting for this, the attenuation curve developed by Seed and Schnabel, Figure 5, was used to define the adjustments in the Port Hueneme bedrock motion necessary to characterize bedrock motion at the interchange site.

6. Implementation of the required adjustments was done using "SHAKE 3", with the resulting bedrock motion applied to the four profiles representing the site. The motion parameters characterizing the surface ground response of each profile during the Point Mugu earthquake were thus obtained and are presented in Table 2.

TABLE 2

SURFACE GROUND RESPONSE AT THE PROPOSED INTERCHANGE SITE

Profile	Maximum Acceleration	Predominant Period	Duration of Strong Motion
1	.11 g	.25 sec.	7 sec.
2	.11 g	.25 sec.	7 sec.
3	.10 g	.25 sec.	7 sec.
4	.10 g	.25 sec.	7 sec.

In order to determine the damage causing potential of the computed ground motion a comparison was made with ground motions associated with the least severe design earthquakes recommended in the Woodward-McNeill report. Table 3 illustrates this comparison.

TABLE 3

COMPARISON OF EARTHQUAKE CHARACTERISTICS

EARTHQUAKE	FAULT	MAGNITUDE	PREDOMINANT PERIOD	DURATION OF STRONG MOTION	MAXIMUM BEDROCK ACCELERATION	MAXIMUM SURFACE ACCELERATION
			Sec.	Sec.	G	G
PT. MUGU	MALIBU-SANTA MONICA-RAYMOND HILL	5.75	0.25	7	0.05	0.11
OBE-1	OAK RIDGE	5.3	0.23	10	0.20	0.26
OBE-2	SAN ANDREAS	7.5	0.45	40	0.10	0.20

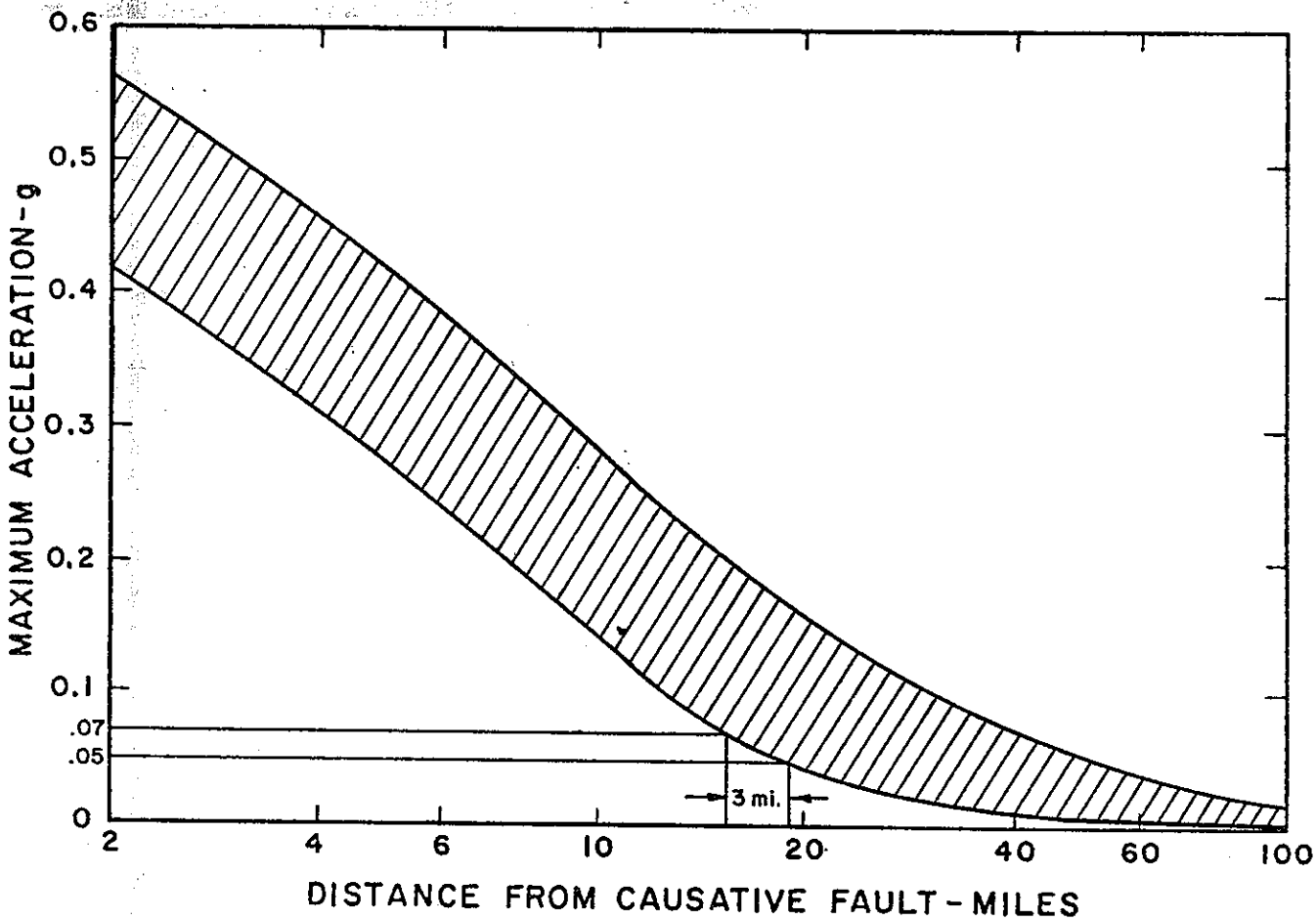


Fig. 5 RANGES OF MAXIMUM ACCELERATIONS IN ROCK FOR A MAGNITUDE 5.75 EARTHQUAKE [4]

It can be seen that ground motion at the interchange site due to the Point Mugu earthquake was well below the severity of either of the design earthquakes. Since the OBE-1 and OBE-2 events had been chosen as those from which the project should sustain little or no damage, it is evident that the damage potential of the February 21, 1973 earthquake to the proposed interchange was not significant. This conclusion is substantiated by the minor damage sustained by existing highway facilities in the immediate vicinity of the proposed interchange.

D. Liquefaction and Seismic Settlement

A comprehensive investigation and analysis of liquefaction potential and seismic settlement at the proposed site was conducted by Woodward and McNeill and presented in their report. Their results show that for the OBE-1 earthquake it should be considered likely that localized liquefaction would occur; however, the presence of embankments would tend to reduce this potential.

Ground motion parameters computed here for the Point Mugu earthquake indicate much less violent excitation than that associated with the OBE-1 event. It must also be noted that there was no evidence of liquefaction observed at the site following the February 21 earthquake.

Again referring to analytical results presented in the Woodward-McNeill report, seismic settlement would not be significant provided cohesive soils compacted to 95% relative compaction are used for embankment construction.

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